Applicant : Jack Yiu-Bun Lee   Attorney's Docket No.: 17329-004001
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Amendment to the Claims:

This listing of claims replaces all prior versions, and listings, of claims in the application:

2. (**Currently Amended**) A method for handling communication errors in a communication system **for distributing video**, the method comprising:

initiating transmission of an intended group of packets **of a video signal**, the intended group of packets including a set of data and error-correcting information for the set of data;

receiving an indication of at least some data, of the set of data, that failed to be correctly received at a receiver **among a plurality of receivers**;

in response to the indication, retransmitting a second group of packets, the second group of packets comprising less than all data, of the set of data, that failed to be correctly received at the receiver;

wherein less than all data that failed to be correctly received at the receiver is retransmitted in the retransmitting step, and the receiver will be able to obtain the all data, of the set of data, that failed to be correctly received at the receiver by performing **forward** error correction with the retransmitted second group of packets, once received, and correctly received portions of the intended group of packets, as received from the transmission that was initiated in the initiating step; **and**

buffering data at a transmission server which transmits the intended group of packets and at each receiver which receives the intended group of packets to support error correction by both retransmission at the transmission server and the forward

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<u>error correction at the receiver and to allows for continuous</u>

<u>play of the video signal at each receiver</u>.

3. (Previously presented) The method according to claim 2, wherein the communication system comprises a residential broadband network.

4. (<u>**Currently Amended**</u>)The method according to claim 2, wherein ~~the set of data is a portion of a video, and~~ the transmission is a portion of a multicast of the video.

5. (Previously presented) The method according to claim 2, wherein the transmission of the intended group of packets to the receiver is not over the Internet.

6. (Previously presented) The method according to claim 2, wherein the retransmitting is a unicasting.

7. (Previously presented) The method according to claim 2, wherein the indication is received, in the receiving step, via a unicast from the receiver.

8. (Previously presented) The method according to claim 2, further comprising, at the receiver:
    sending the indication, wherein the indication indicates less than all data, of the set of data, that failed to be correctly received at the receiver, wherein the retransmitting step includes retransmitting all data indicated in the indication.

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9. (Previously presented) The method according to claim 8, wherein the sending step is initiated without waiting for all packets of the intended group of packets to either arrive at the receiver or be determined as being lost to the receiver.

10. (Previously presented) The method according to claim 9, wherein the retransmitting step is initiated before every packet of the intended group of packets has either arrived at the receiver or been lost to the receiver.

11. (Previously presented) The method according to claim 2, wherein:

some packets of the intended group of packets were not correctly received at the receiver; and

the method further comprises identifying a minimally-sized set of packets, of the some packets that were not correctly received at the receiver, that would enable recovery at the receiver of all data, of the set of data, not correctly received at the receiver.

12. (Previously presented) The method according to claim 11, wherein:

the intended group of packets includes D intended data packets and R intended redundancy packets and no other data packets or redundancy packets;

M packets of the intended group of packets were not correctly received at the receiver, wherein M is greater than R; and

the step of identifying a minimally-sized set of packets comprises identifying a set of M minus R packets, of the M packets that were not correctly received at the receiver.

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13. (Previously presented) The method according to claim 12, further comprising, at the receiver:

initiating sending at least a portion of the indication if at least R plus one packets of the intended group of packets were not correctly received at the receiver, even before every packet of the intended group of packets has either arrived at the receiver or been determined as being lost to the receiver.

14. (Previously presented) The method according to claim 2, further comprising, at the receiver:

receiving the retransmitted second group of packets; and

performing erasure correction on the second group of packets and the correctly received portions of the intended group of packets whose transmission was initiated in the initiating step to thereby obtain the all data, of the set of data, that failed to be correctly received at the receiver.

15 (**Currently Amended**). A method for receiving video content at a receiver, the method comprising:

receiving packets from a multicasted group of packets, wherein the multicasted group of packets include data and error-correction information for the data;

if packets received without error in the receiving step include less than all the data, whereby some of the data has been lost, hereinafter referred to as lost data, then:

sending a message based on identity of at least some of the lost data;

receiving a retransmission triggered by the sent message, wherein the retransmission includes less than all of the lost data; [[and]]

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recovering all of the lost data using information from the packets received without error in the receiving packets step and using the received retransmission; **and**

buffering received data at the receiver, including data of retransmission, to allow for continuous play of the video content received at the receiver.

16. (Previously presented) The method according to claim 15, wherein the message identifies and requests retransmission of less than all lost data packets of the multicasted group of packets; and wherein the retransmission includes retransmission of the less than all lost data packets of the multicasted group of packets.

17. (Previously presented) The method according to claim 16, wherein the sending step includes sending at least a portion of the message, even before every packet of the multicasted group of packets has either arrived at the receiver or been determined as lost to the receiver.

Claims 18-21: Canceled.

22. (New) The method according to claim 2, wherein the intended group of packets includes D intended data packets and R intended redundancy packets and no other data packets or redundancy packets, wherein R and D are positive integers, and wherein the receiver has a buffer defined by:

$$L_{hybrid}(i) = \left\lceil \frac{(K_i - 1)\left(\widetilde{T}_s + T_{tran} + 2\left(T_i + T_i^+\right)\right) + \left(T_i^+ - T_i^-\right)}{T_s} \right\rceil + \left\lceil \frac{T_i^+ - T_i^-}{T_s} \right\rceil + D + R + 1$$

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wherein

i represents receiver i of N receivers $(0 \leq i \leq N)$;

T_{tran} is a transmission time;

$\tilde{T}s$ is an inter-packet time;

T_i^+ and T_i^- are the maximum delay jitters between a receiver i and the server, and $T_i^+ \geq 0$, $T_i^- \leq 0$.

23.   (New) The method according to claim 22, wherein the transmission server has a buffer defined by:

$$B_{hybrid} = Q_S (D + R) \left\lceil \frac{r_i^{K_i - 1}}{DT_S} \right\rceil$$

where

$$r_i^{K_i - 1} = \tilde{r}_i + (T_i + T_i^+) + (K_i - 2)(T_{tran} + 2(T_i + T_i^+))$$

and

$$\tilde{r}_i = (D + R - 1)\tilde{T}_s + T_{tran} + T_i + T_i^+$$

wherein Qs is a byte size of one packet and Ts is a period of one packet.

24.   (New) The method according to claim 2, wherein the intended group of packets includes D intended data packets and R intended redundancy packets and no other data packets or redundancy packets, wherein R and D are positive integers,

wherein a traffic overhead of the system defined as a ratio between traffic at the server incurred in error recovery and traffic at the server for normal delivery of video signals is:

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$$H_{hybrid}(R) = \frac{R}{D} + h(R)$$

where

$$h(R) = \frac{1}{D}\sum_{i=0}^{N-1}\sum_{m=R+1}^{D+R}(m-R)h_i\binom{D+R}{m}p_i^m(1-p_i)^{D+R-m}$$

$$= \frac{1}{D}\sum_{i=0}^{N-1}\sum_{m=R+1}^{D+R}\sum_{j=1}^{K_i-1}\binom{D+R}{m}j(m-r)p_i^{m+j-1}(1-p_i)^{D+R-m+1}$$

and

$$h_i = \sum_{j=1}^{K_i-1}j\left(p_i^{j-1}(1-p_i)\right)$$

$$K_i = \left\lceil \frac{\ln p_{max}}{\ln \varepsilon_i}\right\rceil.$$

$$\varepsilon_i = \sum_{k=R+1}^{D+R}\frac{k}{D+R}\Phi_i(k)$$

$$\Phi_i(k) = \sum_{m=k}^{D+R}\binom{m-R}{k-R}\left(p_i^{K_i-1}\right)^{k-R}\left(1-p_i^{K_i-1}\right)^{m-k}\binom{D+R}{m}p_i^m(1-p_i)^{D+R-m}, \quad k \geq R$$

wherein

$H_{hybrid}(R)$ is the traffic overhead of the system,

N is the number of receivers in the system,

i means the receiver i, and $0 \leq i \leq N$,

p_{max} is a maximum tolerable packet-loss probability for the data,

p_i is a pack loss probability experienced by receiver I,

ε_i is a residual loss probability of a receiver I;
the method further comprising selecting the redundancy R to be a value between 0 and

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$$R_{FEC} = \min\{R \mid \varepsilon_i \le p_{max}, \forall i\}$$

to minimize $H_{hybrid}(R)$.

25. **(New)** A method for delivering video in a broadband network, comprising:

buffering video data, retransmission data for implementing automatic repeat request and redundancy data for implementing forward error correction at a server and each of a plurality of receivers in the network to support error correction by both retransmission under the automatic repeat request and the forward error correction;

configuring buffer space at the receiver and each receiver, to allow for continuous play of the video received at the receiver; and

performing both retransmission under the automatic repeat request and the forward error correction to correct errors in video data received at each receiver to reduce traffic overhead at the server.

26. **(New)** The method according to claim 25, further comprising:

performing retransmission under the automatic repeat request first upon detecting a transmission error; and

after a retransmission is performed, performing the forward error correction on the retransmitted data.

27. **(New)** The method according to Claim 26, wherein the data transmitted from the server includes D intended data packets and R intended redundancy packets, wherein R and D are

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positive integers, and wherein the receiver has a buffer defined by:

$$L_{hybrid}(i) = \left\lceil \frac{(K_i - 1)(\tilde{T}_s + T_{tran} + 2(T_i + T_i^+)) + (T_i^+ - T_i^-)}{\tilde{T}_s} \right\rceil + \left\lceil \frac{T_i^+ - T_i^-}{\tilde{T}_s} \right\rceil + D + R + 1$$

wherein

i represents receiver i of N receivers ($0 \leq i \leq N$);

T_{tran} is a transmission time;

$\tilde{T}_s$ is an inter-packet time;

T_i^+ and T_i^- are the maximum delay jitters between a receiver i and the server, and $T_i^+ \geq 0$, $T_i^- \leq 0$.

28. **(New)** The method according to claim 27, wherein the server has a buffer defined by:

$$B_{hybrid} = Q_S (D + R) \left\lceil \frac{r_i^{K_i - 1}}{DT_S} \right\rceil$$

where

$$r_i^{K_i - 1} = \tilde{r}_i + (T_i + T_i^+) + (K_i - 2)(T_{tran} + 2(T_i + T_i^+))$$

and

$$\tilde{r}_i = (D + R - 1)\tilde{T}_s + T_{tran} + T_i + T_i^+$$

wherein Qs is a byte size of one packet and Ts is a period of one packet.

29. **(New)** The method according to claim 25, wherein the data transmitted from the server includes D intended data packets and R intended redundancy packets, wherein R and D are positive integers,

wherein a traffic overhead of the system defined as a ratio between traffic at the server incurred in error recovery and traffic at the server for normal delivery of video signals is:

$$H_{hybrid}(R) = \frac{R}{D} + h(R)$$

where

$$h(R) = \frac{1}{D} \sum_{i=0}^{N-1} \sum_{m=R+1}^{D+R} (m-R) h_i \binom{D+R}{m} p_i^m (1-p_i)^{D+R-m}$$

$$= \frac{1}{D} \sum_{i=0}^{N-1} \sum_{m=R+1}^{D+R} \sum_{j=1}^{K_i-1} \binom{D+R}{m} j(m-r) p_i^{m+j-1} (1-p_i)^{D+R-m+1}$$

and

$$h_i = \sum_{j=1}^{K_i-1} j\left(p_i^{j-1}(1-p_i)\right)$$

$$K_i = \left\lceil \frac{\ln p_{max}}{\ln \varepsilon_i} \right\rceil.$$

$$\varepsilon_i = \sum_{k=R+1}^{D+R} \frac{k}{D+R} \Phi_i(k)$$

$$\Phi_i(k) = \sum_{m=k}^{D+R} \binom{m-R}{k-R} \left(p_i^{K_i-1}\right)^{k-R} \left(1-p_i^{K_i-1}\right)^{m-k} \binom{D+R}{m} p_i^m (1-p_i)^{D+R-m}, \quad k \geq R$$

wherein

$H_{hybrid}(R)$ is the traffic overhead of the system,

N is the number of receivers in the system,

i means the receiver i, and $0 \leq i \leq N$,

p_{max} is a maximum tolerable packet-loss probability for the data,

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p_i is a pack loss probability experienced by receiver I,

ε_i is a residual loss probability of a receiver I;
the method further comprising selecting the redundancy R to be a value between 0 and

$$R_{FEC} = \min\{R \mid \varepsilon_i \le p_{max}, \forall i\}$$

to minimize $H_{hybrid}(R)$.

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